Figure 1

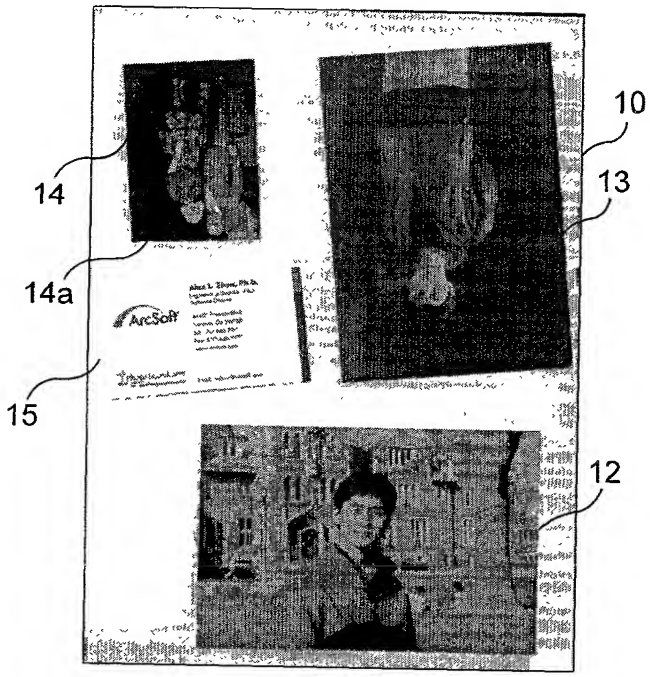
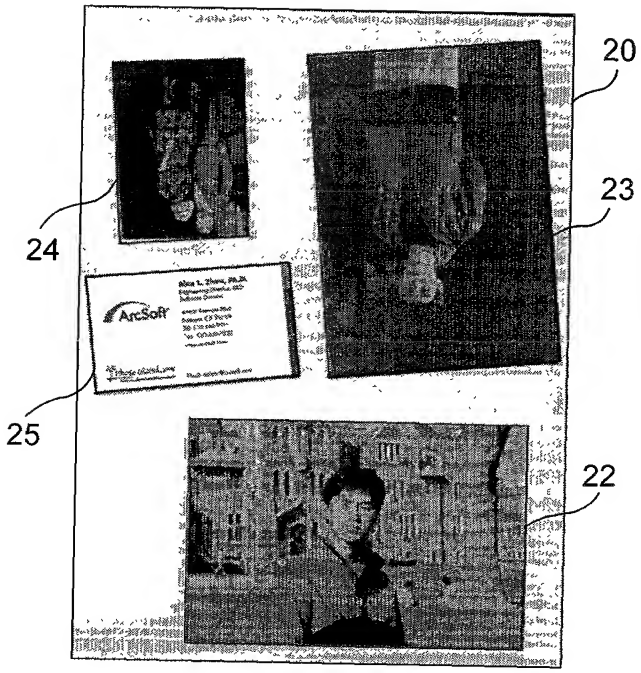


Figure 2



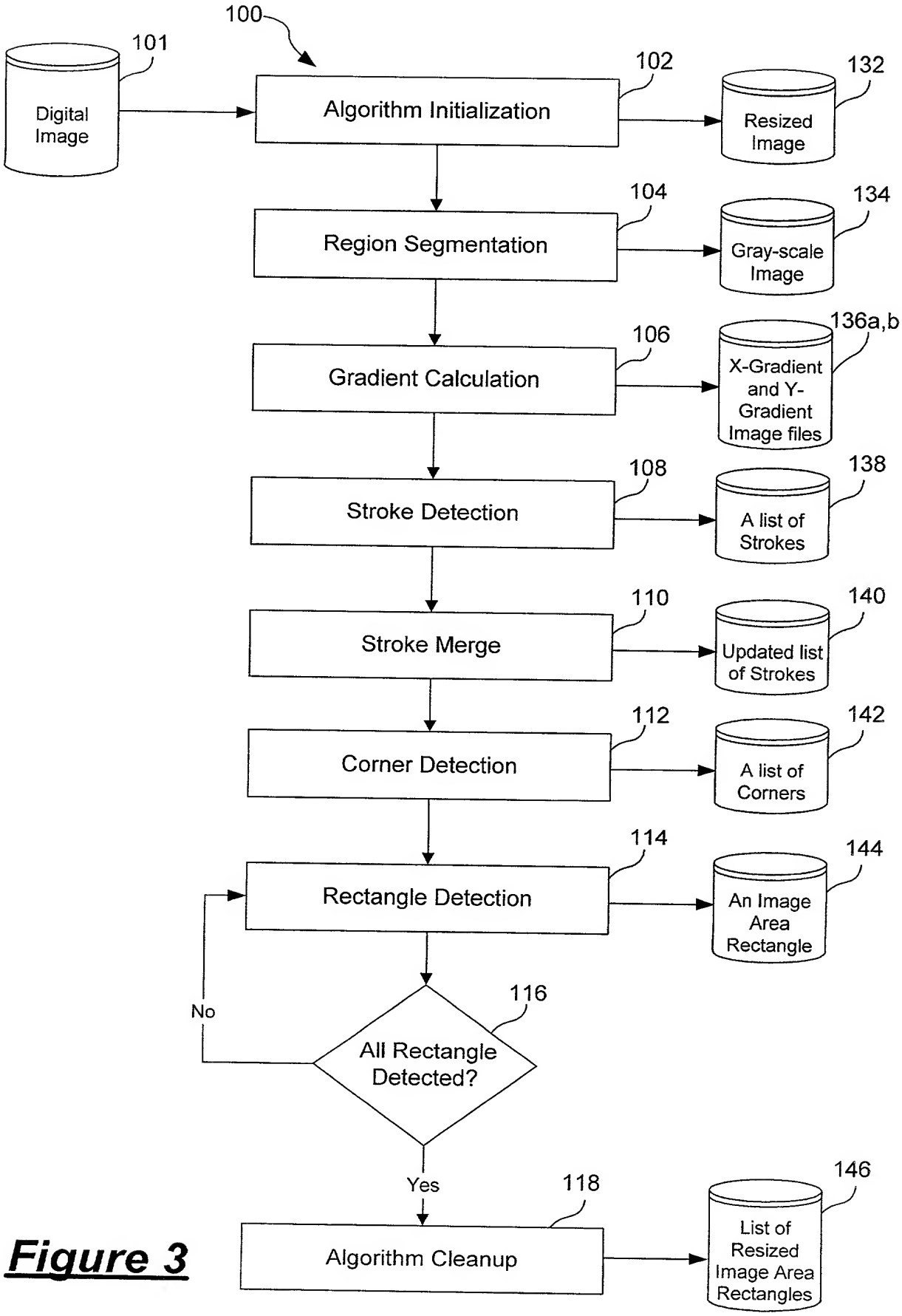

100
101
Digital Image
Algorithm Initialization
102
132
Resized Image
Region Segmentation
104
134
Gray-scale Image
Gradient Calculation
106
136a,b
X-Gradient and Y-Gradient Image files
Stroke Detection
108
138
A list of Strokes
Stroke Merge
110
140
Updated list of Strokes
Corner Detection
112
142
A list of Corners
Rectangle Detection
114
144
An Image Area Rectangle
No
All Rectangle Detected?
116
Yes
Algorithm Cleanup
118
146
List of Resized Image Area Rectangles

Figure 3

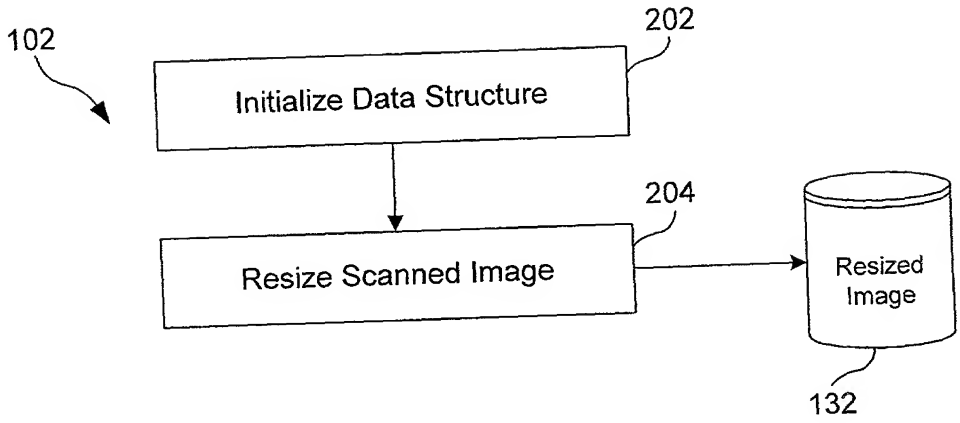


Figure 4

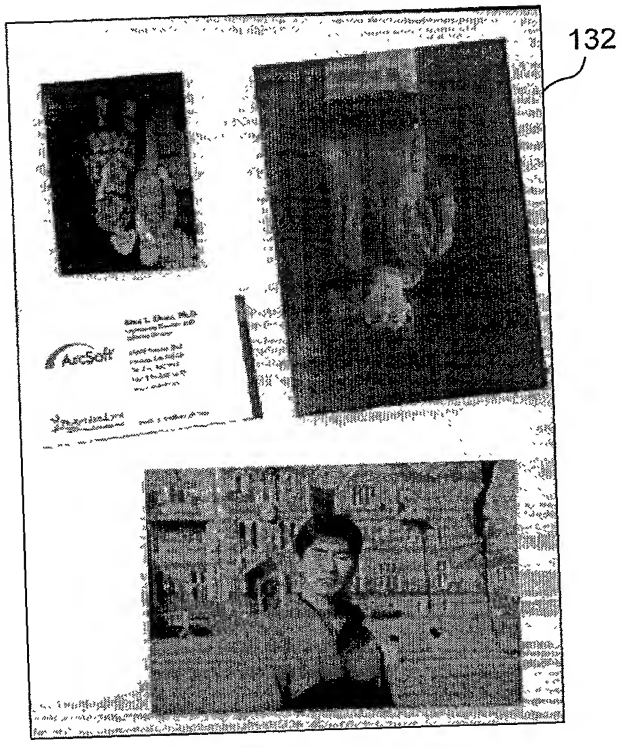


Figure 5

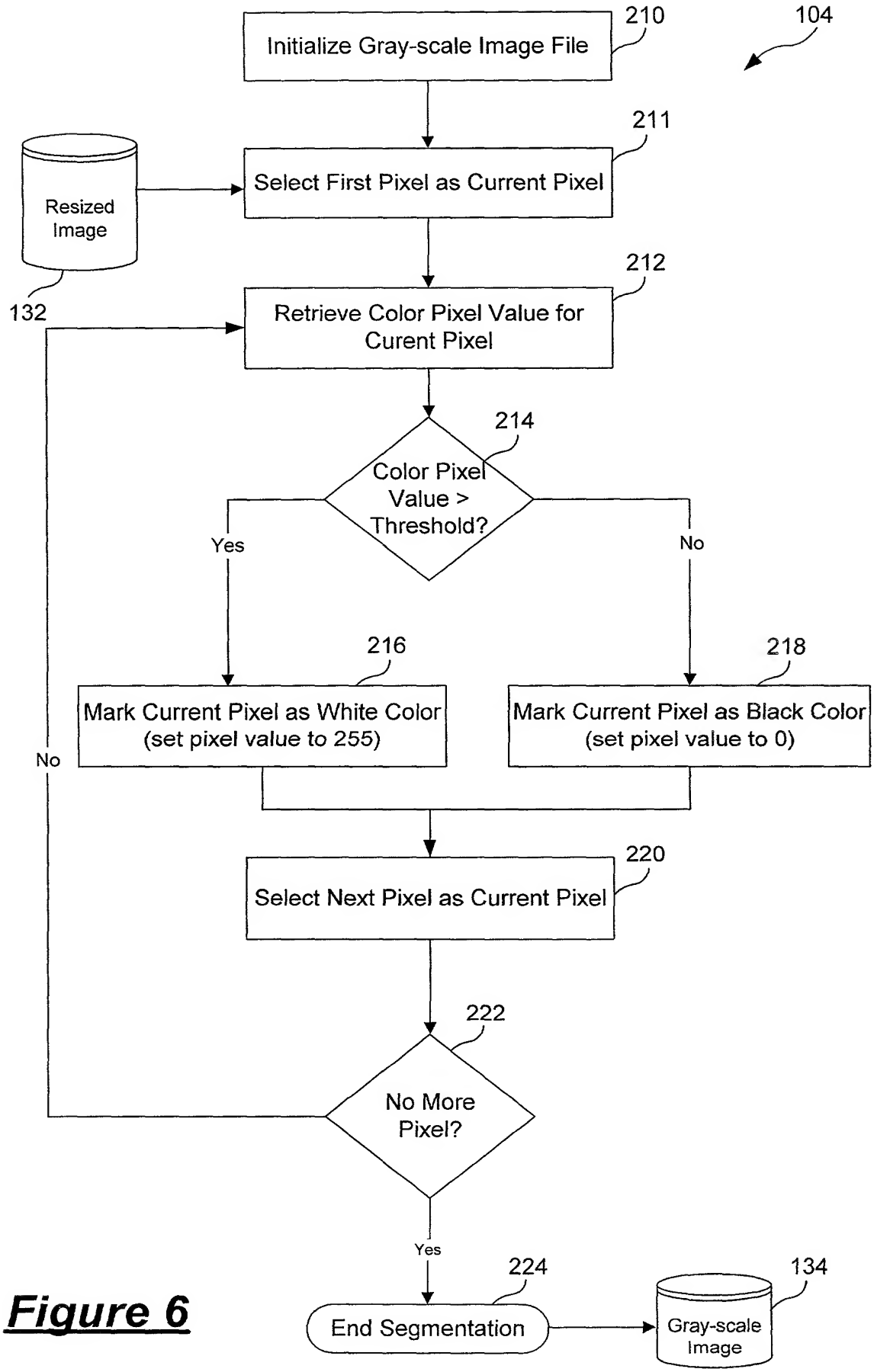

104
Initialize Gray-scale Image File
210
Select First Pixel as Current Pixel
211
Resized Image
132
Retrieve Color Pixel Value for Curent Pixel
212
Color Pixel Value > Threshold?
214
Yes
No
Mark Current Pixel as White Color (set pixel value to 255)
216
Mark Current Pixel as Black Color (set pixel value to 0)
218
No
Select Next Pixel as Current Pixel
220
No More Pixel?
222
Yes
End Segmentation
224
Gray-scale Image
134

Figure 6

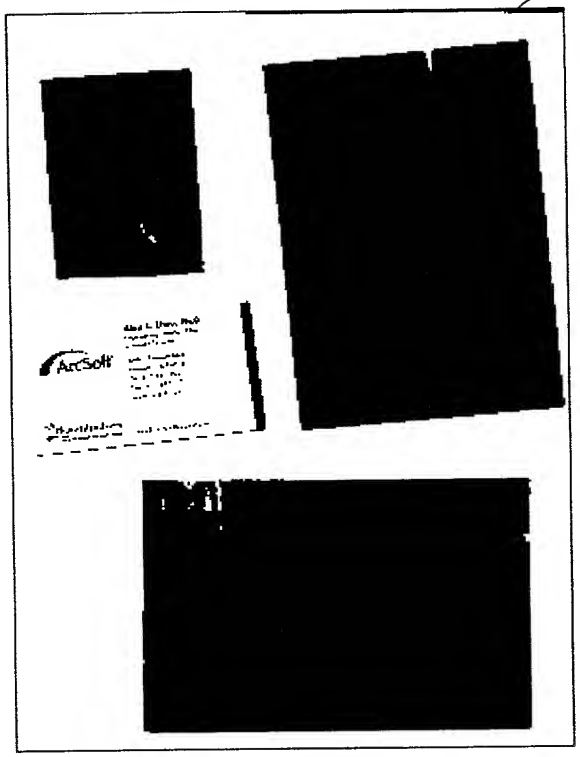


Figure 7

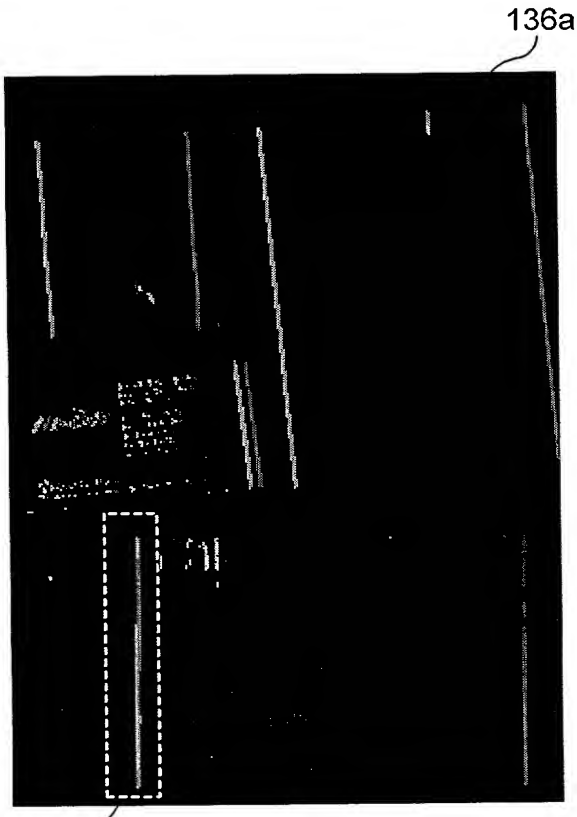


Figure 9a

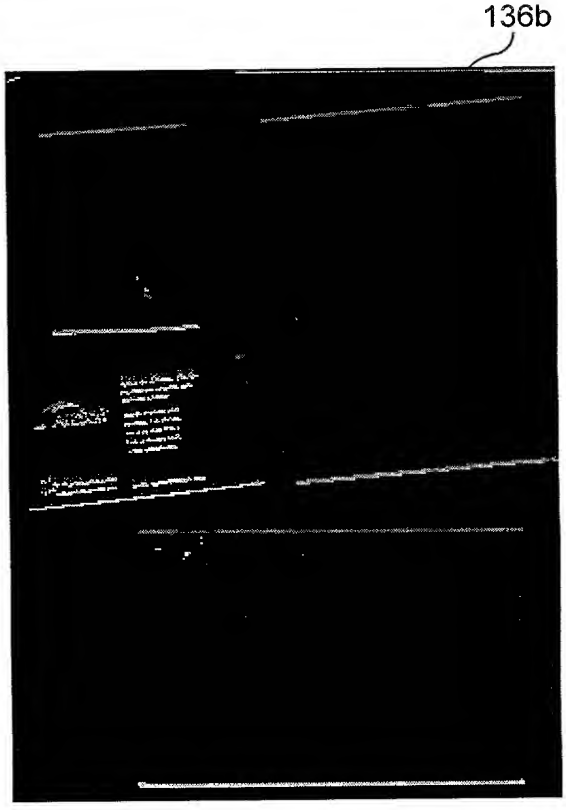


Figure 9b

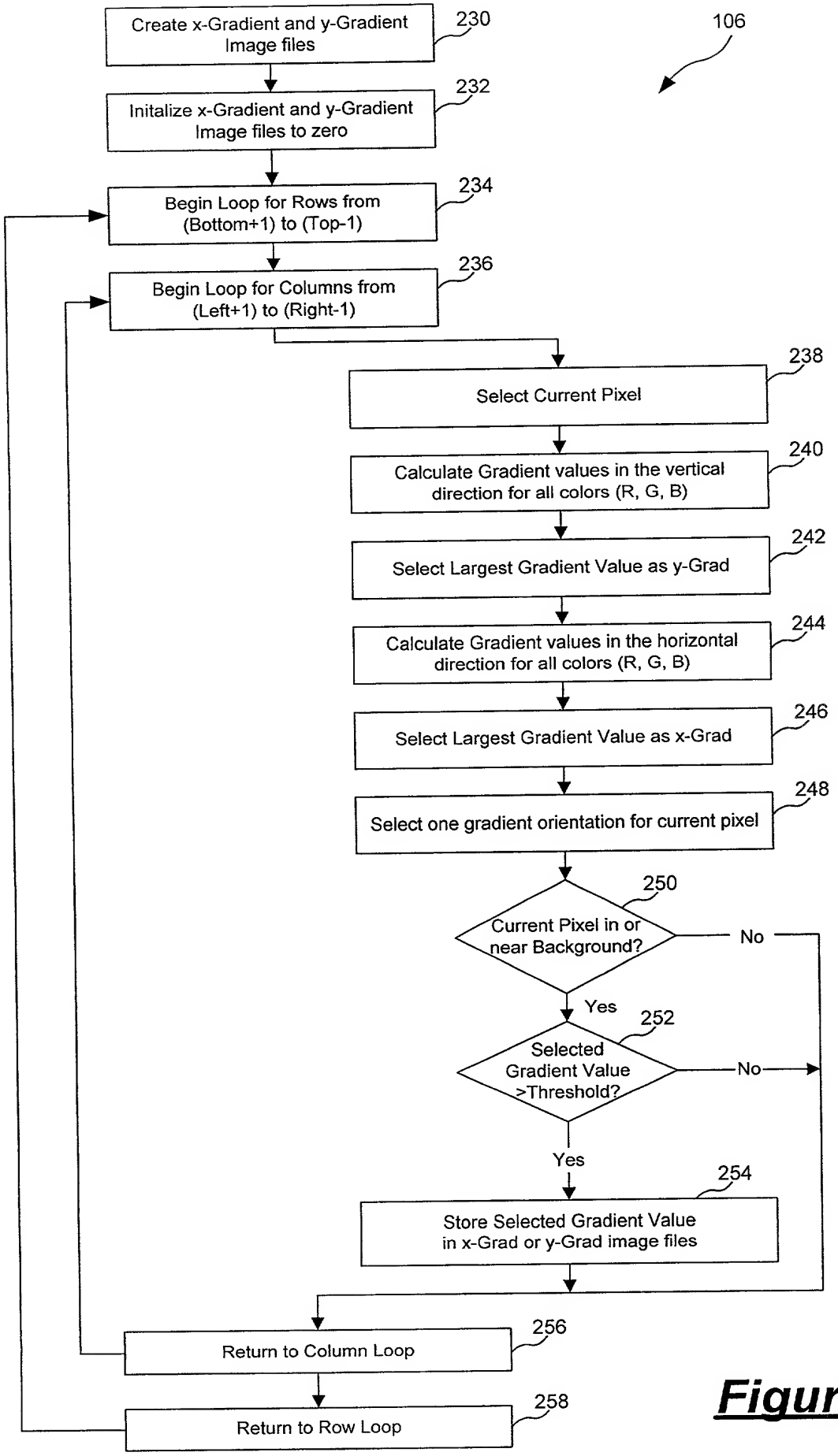

106
Create x-Gradient and y-Gradient Image files
230
Initalize x-Gradient and y-Gradient Image files to zero
232
Begin Loop for Rows from (Bottom+1) to (Top-1)
234
Begin Loop for Columns from (Left+1) to (Right-1)
236
Select Current Pixel
238
Calculate Gradient values in the vertical direction for all colors (R, G, B)
240
Select Largest Gradient Value as y-Grad
242
Calculate Gradient values in the horizontal direction for all colors (R, G, B)
244
Select Largest Gradient Value as x-Grad
246
Select one gradient orientation for current pixel
248
Current Pixel in or near Background?
250
No
Yes
Selected Gradient Value >Threshold?
252
No
Yes
Store Selected Gradient Value in x-Grad or y-Grad image files
254
Return to Column Loop
256
Return to Row Loop
258

Figure 8

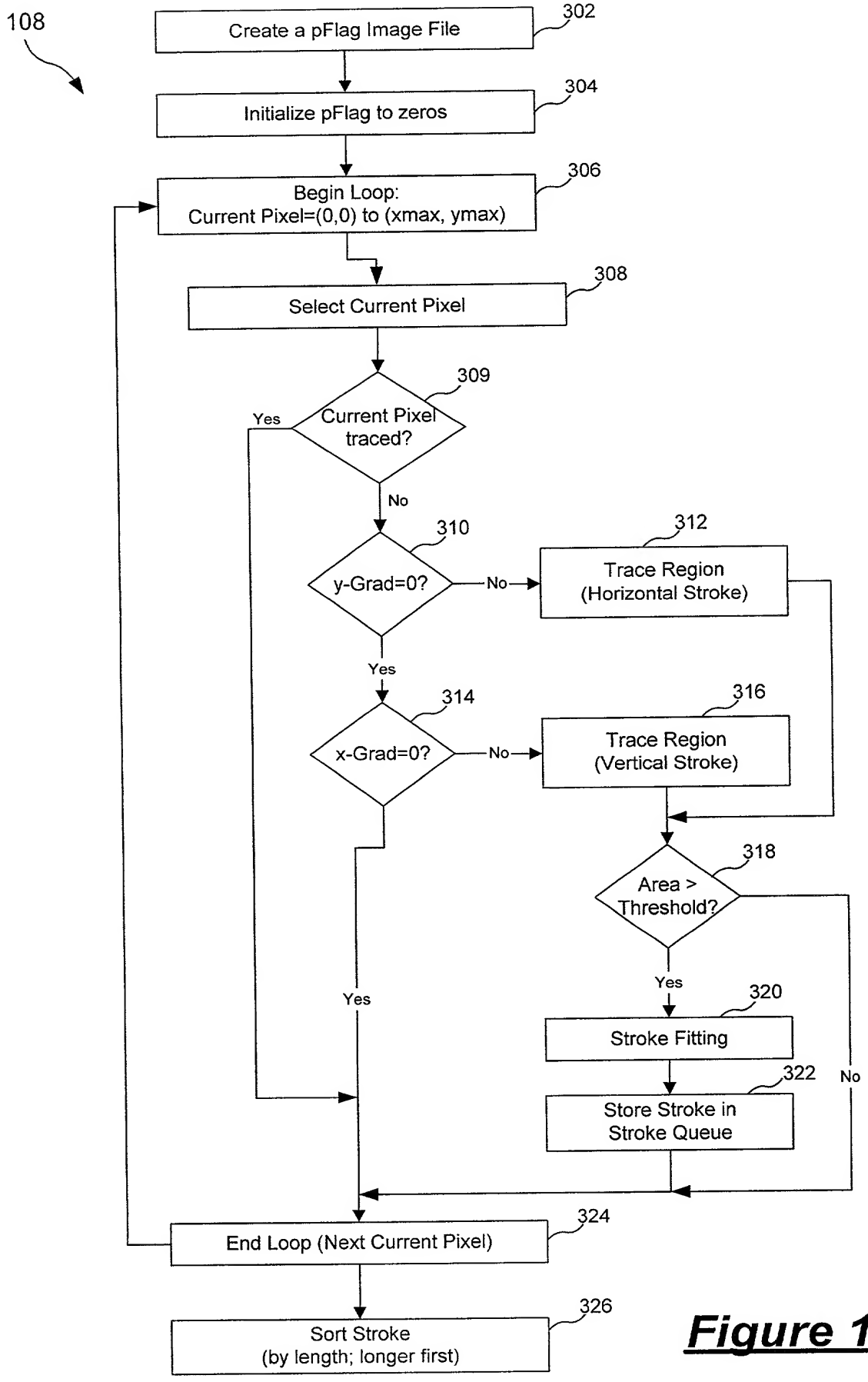

108
Create a pFlag Image File
302
Initialize pFlag to zeros
304
Begin Loop:
Current Pixel=(0,0) to (xmax, ymax)
306
Select Current Pixel
308
Current Pixel traced?
309
Yes
No
y-Grad=0?
310
No
Trace Region (Horizontal Stroke)
312
Yes
x-Grad=0?
314
No
Trace Region (Vertical Stroke)
316
Area > Threshold?
318
Yes
Yes
Stroke Fitting
320
Store Stroke in Stroke Queue
322
No
End Loop (Next Current Pixel)
324
Sort Stroke
(by length; longer first)
326

Figure 10

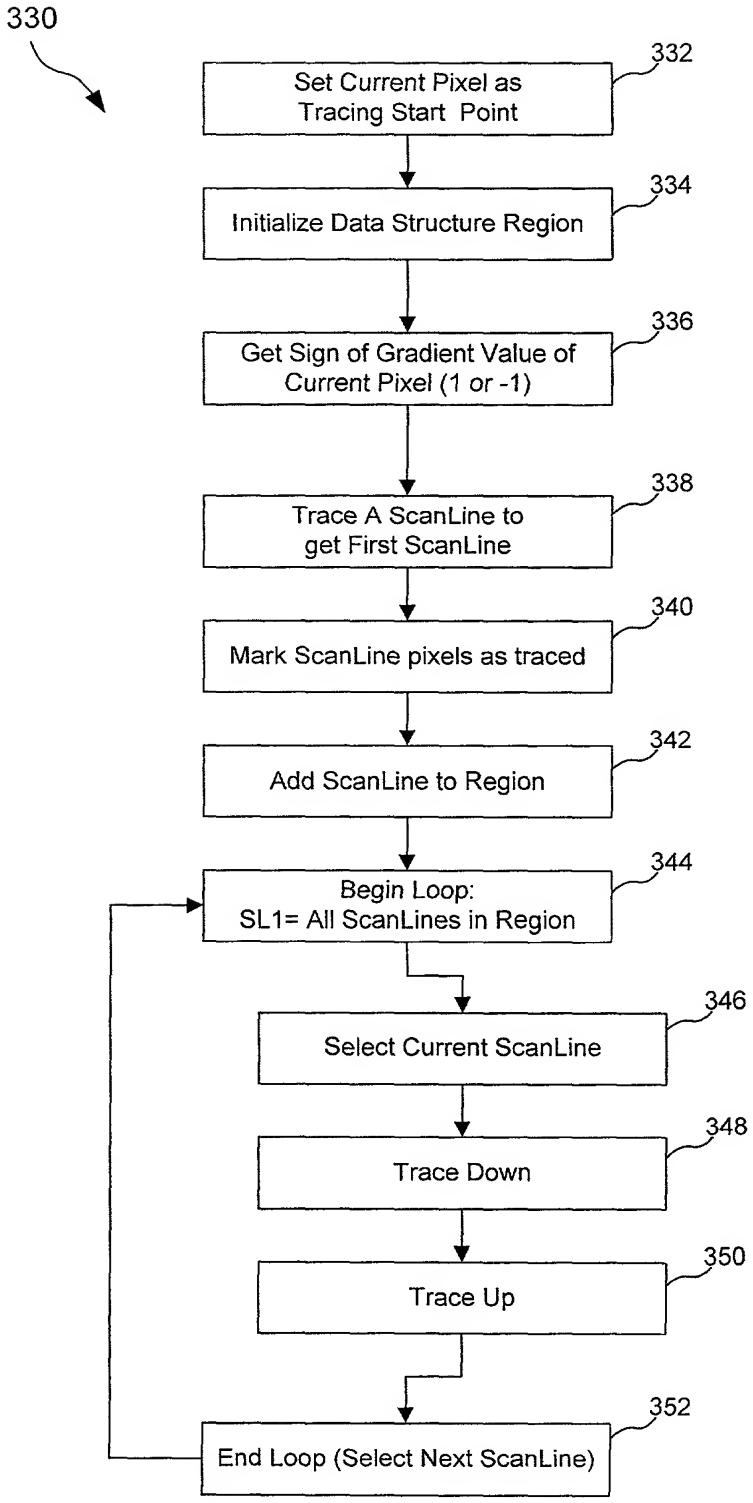

330
Set Current Pixel as Tracing Start Point
332
Initialize Data Structure Region
334
Get Sign of Gradient Value of Current Pixel (1 or -1)
336
Trace A ScanLine to get First ScanLine
338
Mark ScanLine pixels as traced
340
Add ScanLine to Region
342
Begin Loop: SL1= All ScanLines in Region
344
Select Current ScanLine
346
Trace Down
348
Trace Up
350
End Loop (Select Next ScanLine)
352

Figure 11

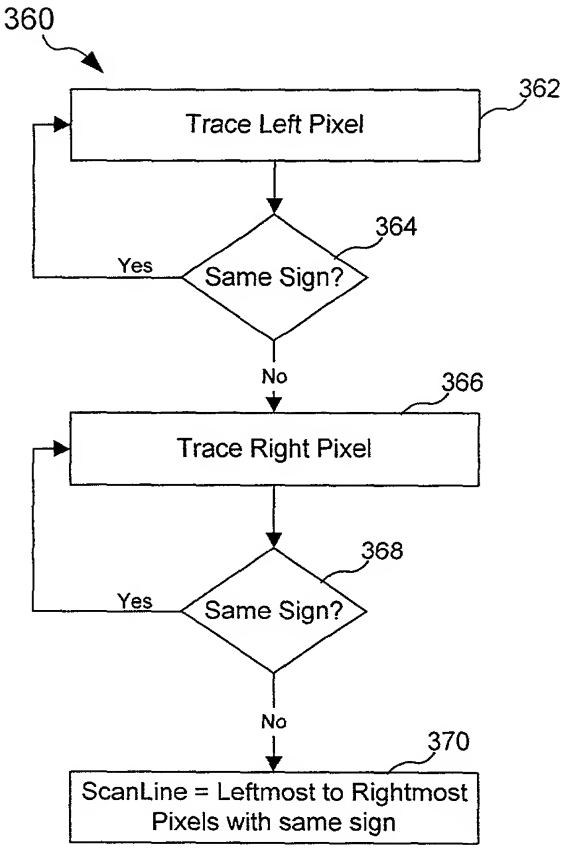


Figure 12

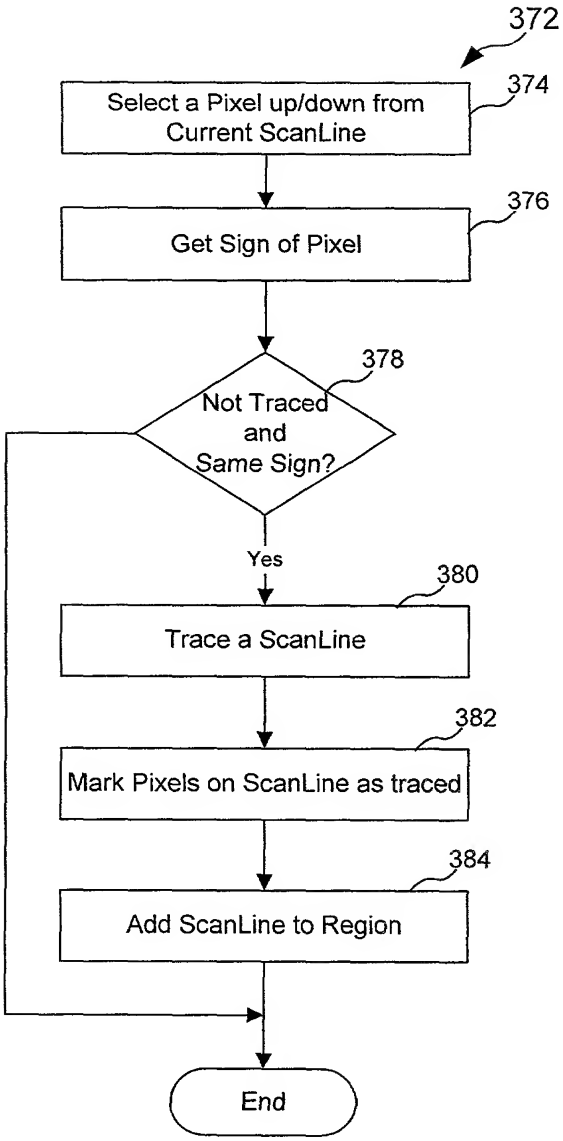


Figure 13

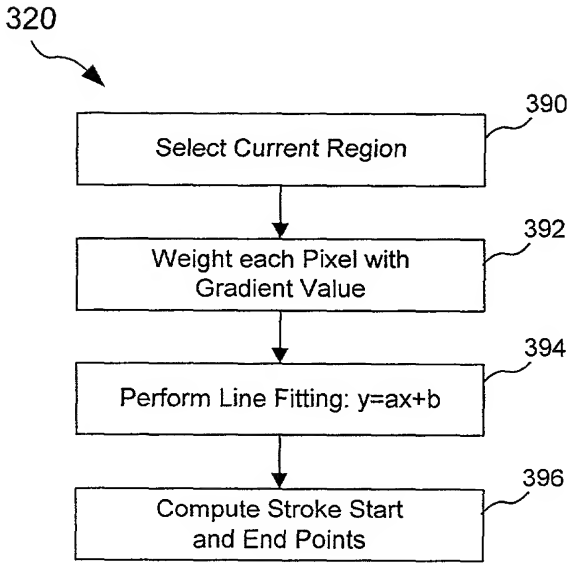


Figure 14

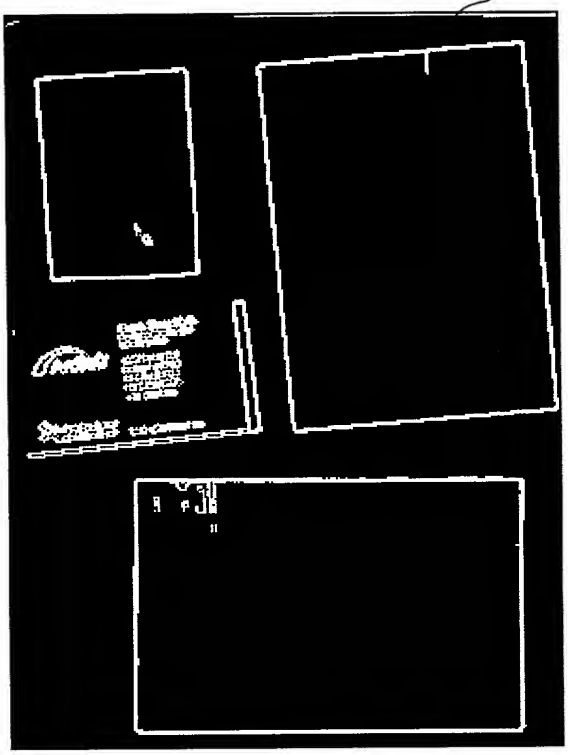


Figure 15

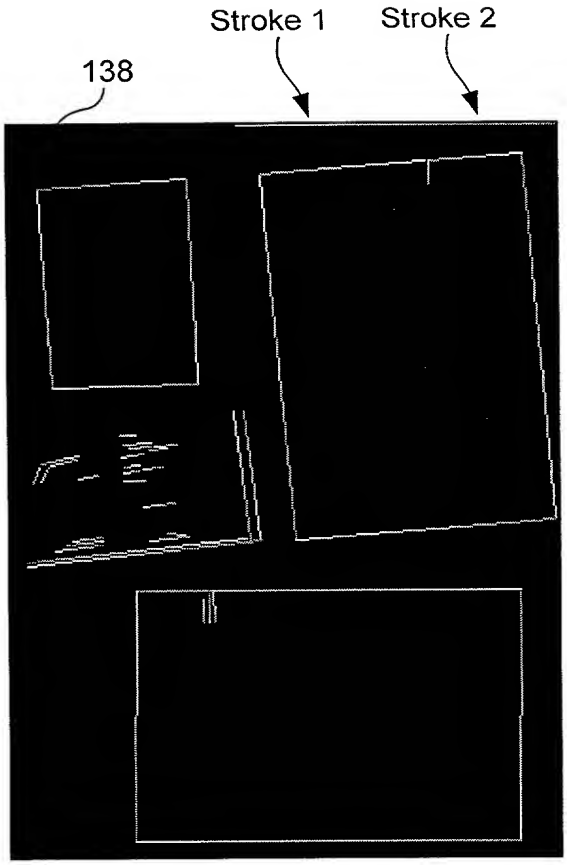


Figure 16

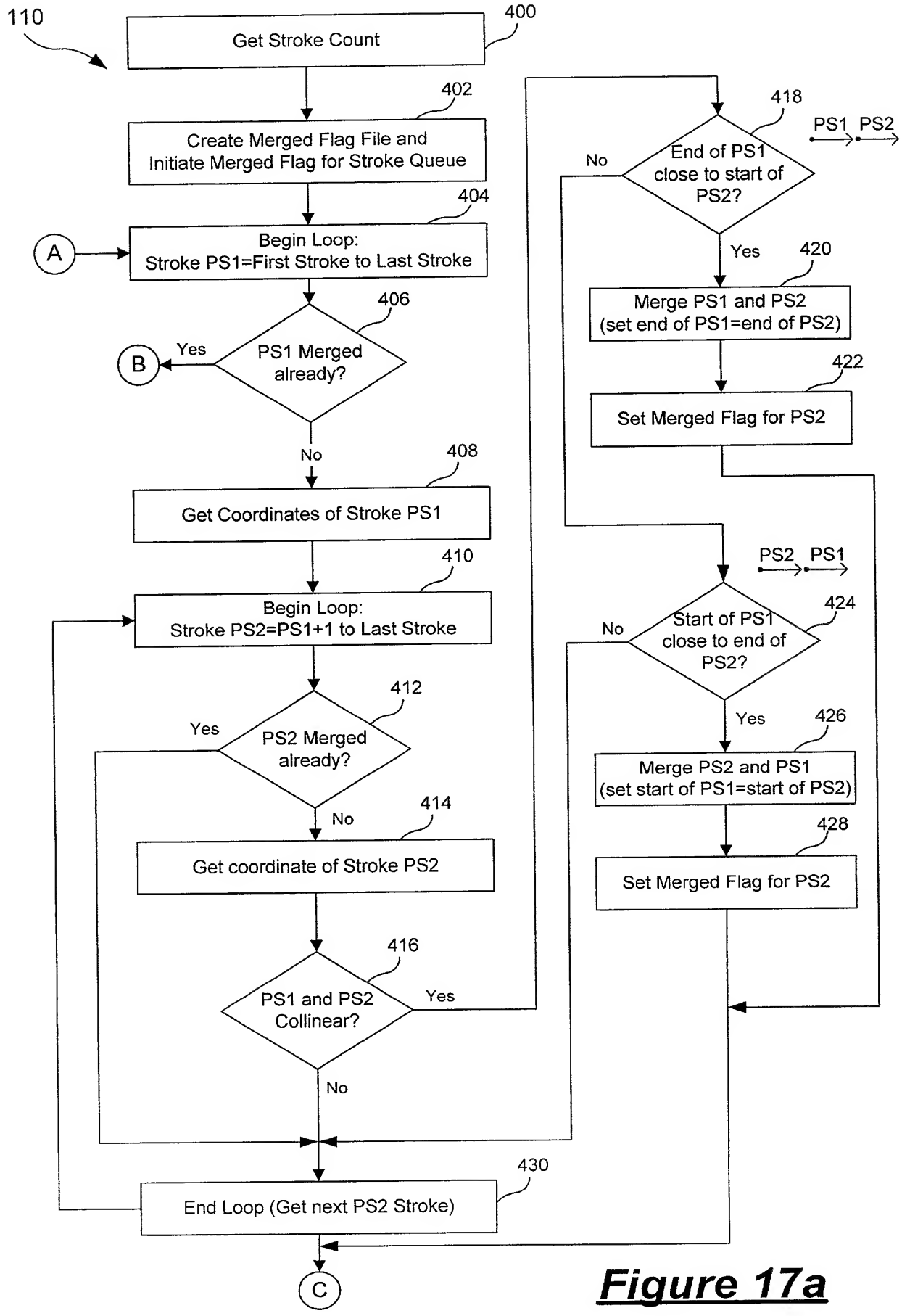

110
Get Stroke Count
400
Create Merged Flag File and Initiate Merged Flag for Stroke Queue
402
Begin Loop: Stroke PS1=First Stroke to Last Stroke
404
A
PS1 Merged already?
406
Yes
B
No
Get Coordinates of Stroke PS1
408
Begin Loop: Stroke PS2=PS1+1 to Last Stroke
410
PS2 Merged already?
412
Yes
No
Get coordinate of Stroke PS2
414
PS1 and PS2 Collinear?
416
Yes
No
End Loop (Get next PS2 Stroke)
430
C
End of PS1 close to start of PS2?
418
PS1 PS2
No
Yes
Merge PS1 and PS2 (set end of PS1=end of PS2)
420
Set Merged Flag for PS2
422
PS2 PS1
Start of PS1 close to end of PS2?
424
No
Yes
Merge PS2 and PS1 (set start of PS1=start of PS2)
426
Set Merged Flag for PS2
428

Figure 17a

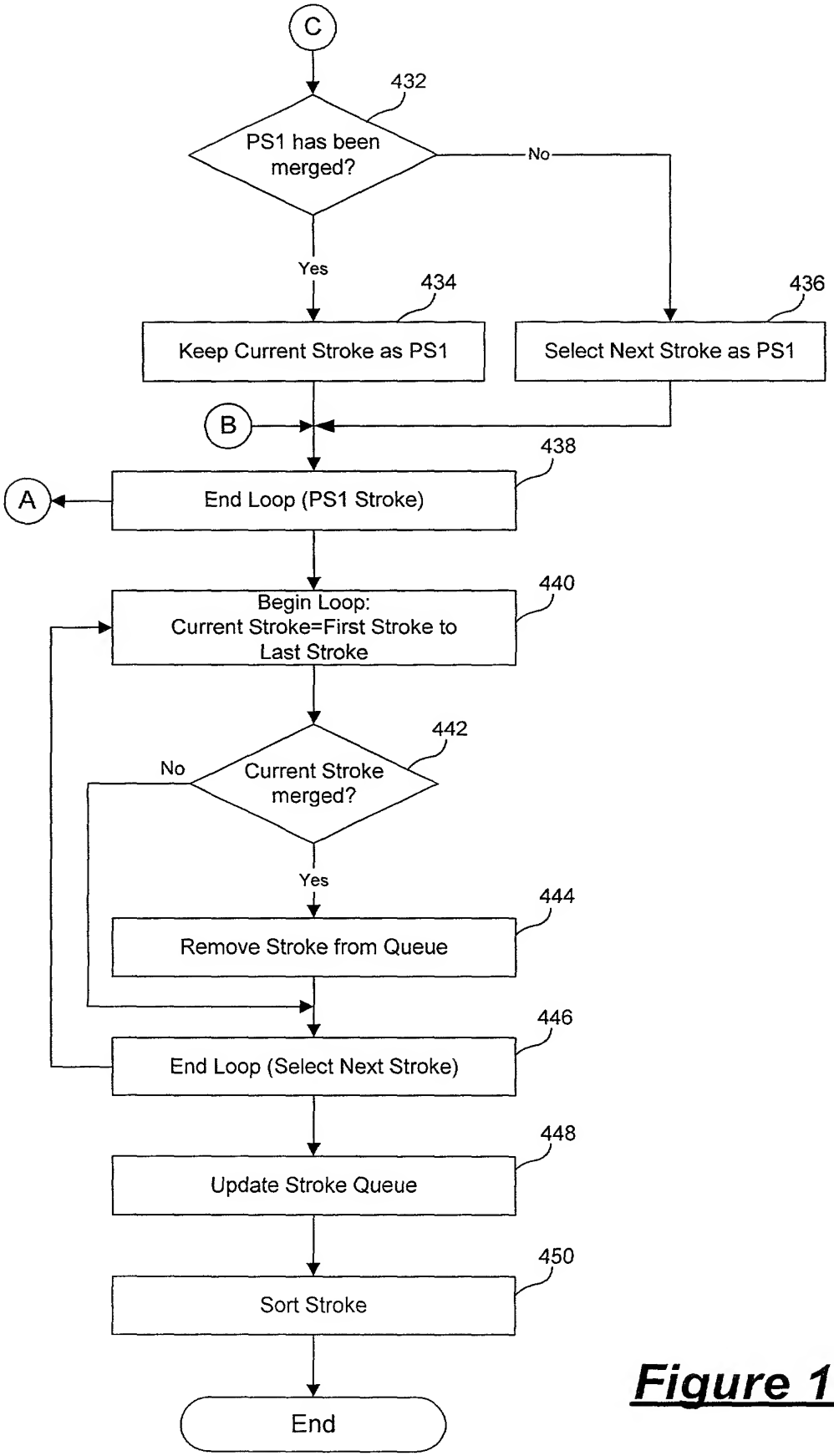

C
432
PS1 has been merged?
No
Yes
434
436
Keep Current Stroke as PS1
Select Next Stroke as PS1
B
438
A
End Loop (PS1 Stroke)
440
Begin Loop: Current Stroke=First Stroke to Last Stroke
442
No
Current Stroke merged?
Yes
444
Remove Stroke from Queue
446
End Loop (Select Next Stroke)
448
Update Stroke Queue
450
Sort Stroke
End

Figure 17b

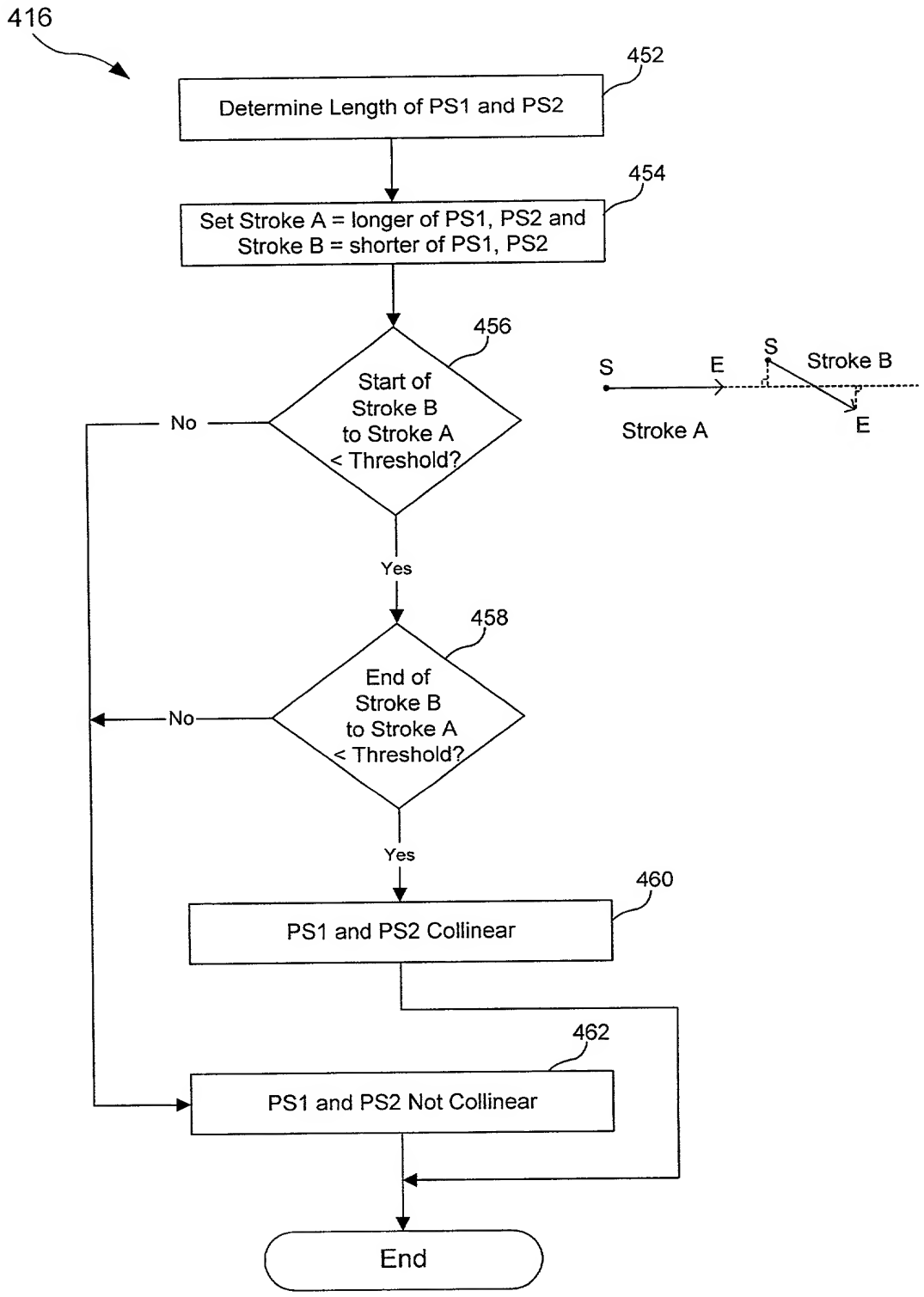

416
452
Determine Length of PS1 and PS2
454
Set Stroke A = longer of PS1, PS2 and Stroke B = shorter of PS1, PS2
456
Start of Stroke B to Stroke A < Threshold?
No
Yes
458
End of Stroke B to Stroke A < Threshold?
No
Yes
460
PS1 and PS2 Collinear
462
PS1 and PS2 Not Collinear
End
S
E
S
Stroke B
Stroke A
E

Figure 18

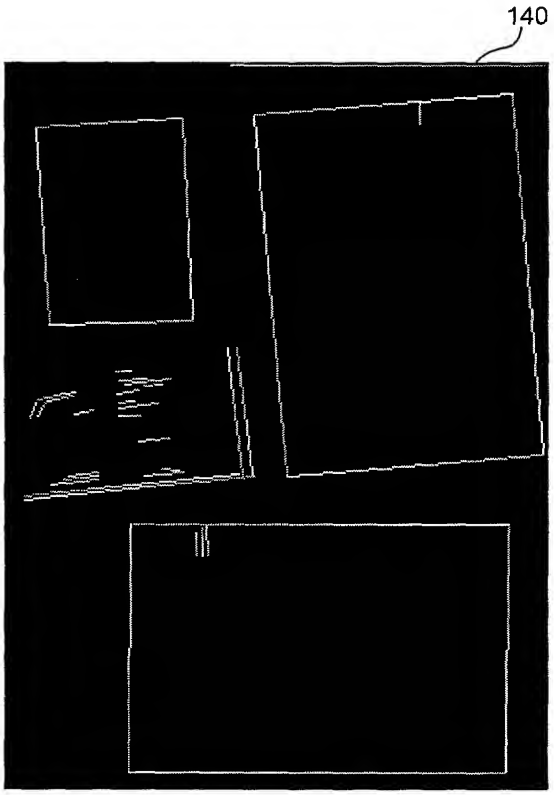


Figure 19

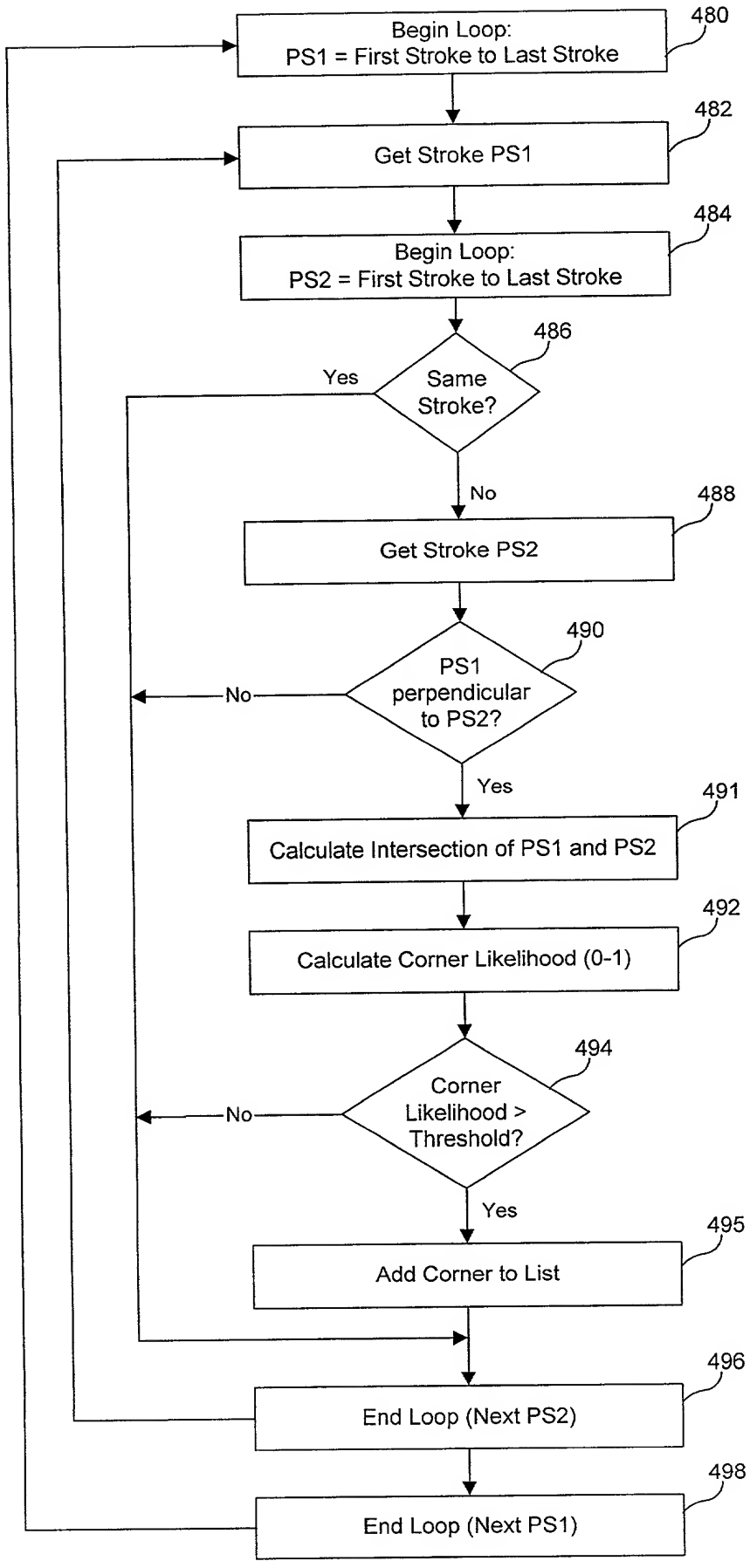

112
Begin Loop:
PS1 = First Stroke to Last Stroke
480
Get Stroke PS1
482
Begin Loop:
PS2 = First Stroke to Last Stroke
484
Same Stroke?
486
Yes
No
Get Stroke PS2
488
PS1 perpendicular to PS2?
490
No
Yes
Calculate Intersection of PS1 and PS2
491
Calculate Corner Likelihood (0-1)
492
Corner Likelihood > Threshold?
494
No
Yes
Add Corner to List
495
End Loop (Next PS2)
496
End Loop (Next PS1)
498

Figure 20

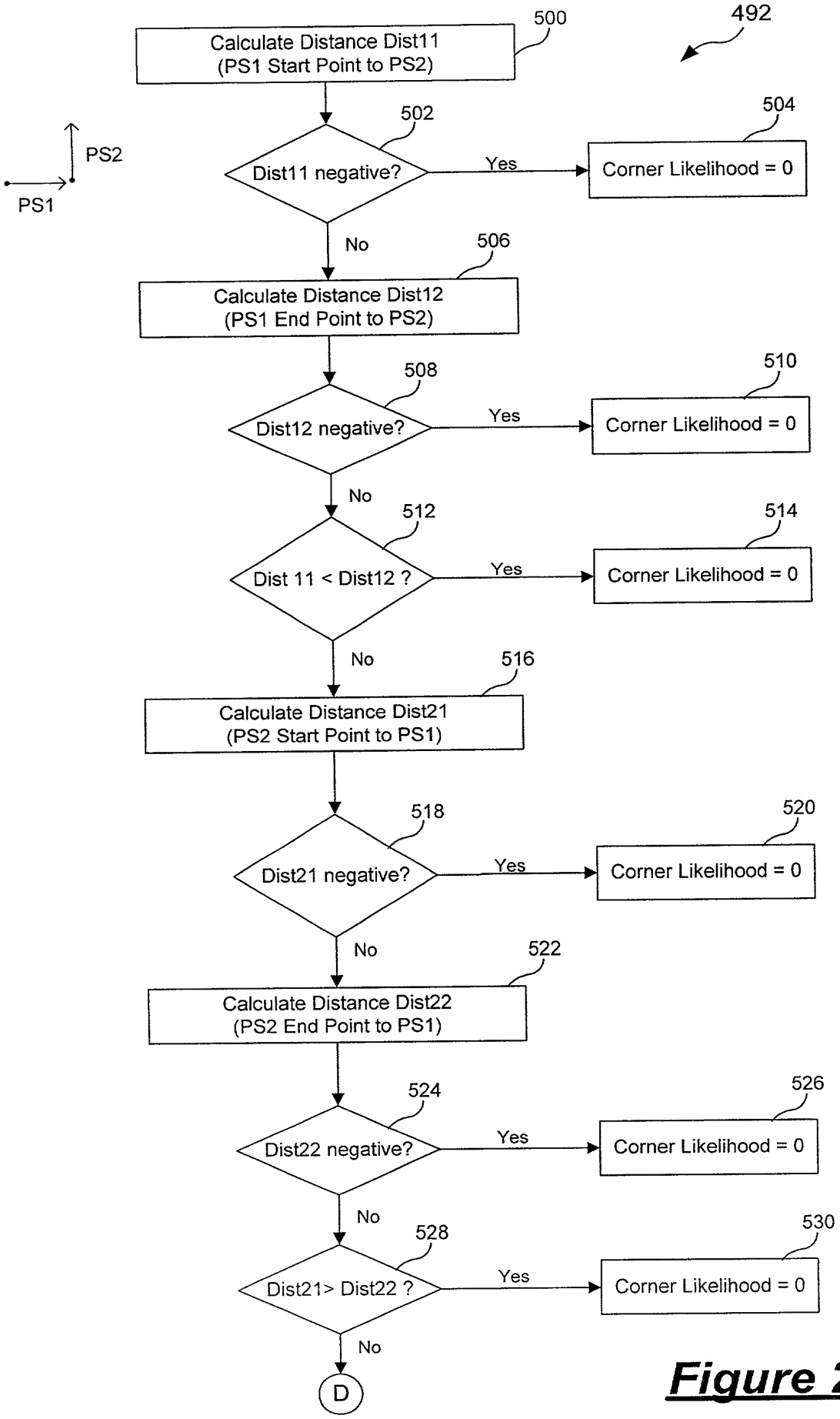

492
500
Calculate Distance Dist11
(PS1 Start Point to PS2)
502
Dist11 negative?
Yes
504
Corner Likelihood = 0
No
506
Calculate Distance Dist12
(PS1 End Point to PS2)
508
Dist12 negative?
Yes
510
Corner Likelihood = 0
No
512
Dist 11 < Dist12 ?
Yes
514
Corner Likelihood = 0
No
516
Calculate Distance Dist21
(PS2 Start Point to PS1)
518
Dist21 negative?
Yes
520
Corner Likelihood = 0
No
522
Calculate Distance Dist22
(PS2 End Point to PS1)
524
Dist22 negative?
Yes
526
Corner Likelihood = 0
No
528
Dist21> Dist22 ?
Yes
530
Corner Likelihood = 0
No
D
PS2
PS1

Figure 21a

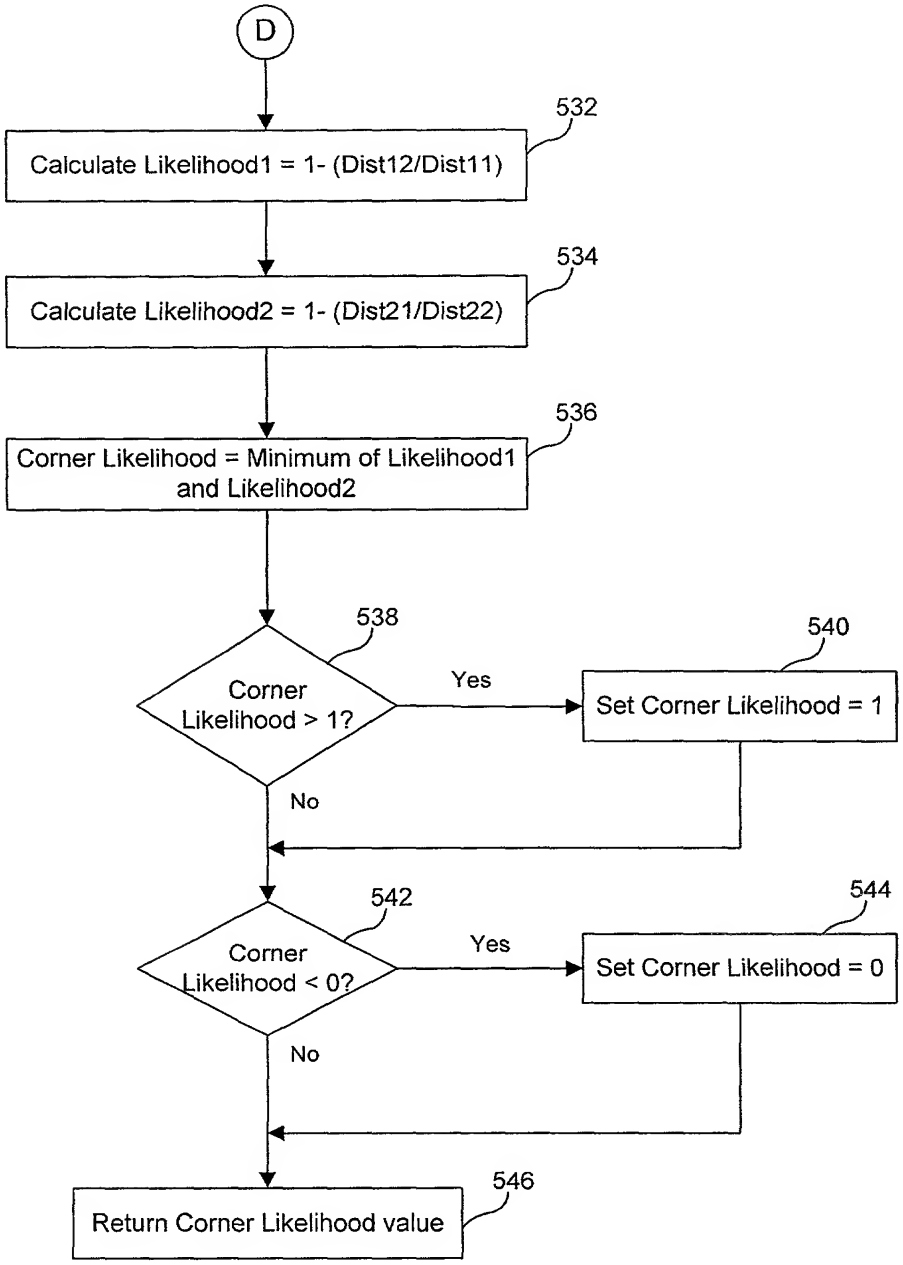

D
532
Calculate Likelihood1 = 1- (Dist12/Dist11)
534
Calculate Likelihood2 = 1- (Dist21/Dist22)
536
Corner Likelihood = Minimum of Likelihood1 and Likelihood2
538
Corner Likelihood > 1?
Yes
540
Set Corner Likelihood = 1
No
542
Corner Likelihood < 0?
Yes
544
Set Corner Likelihood = 0
No
546
Return Corner Likelihood value

Figure 21b

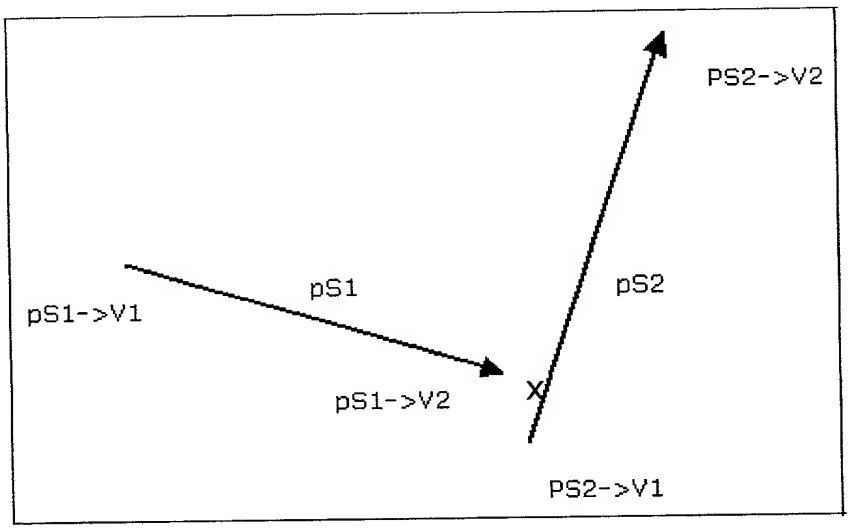


Figure 22

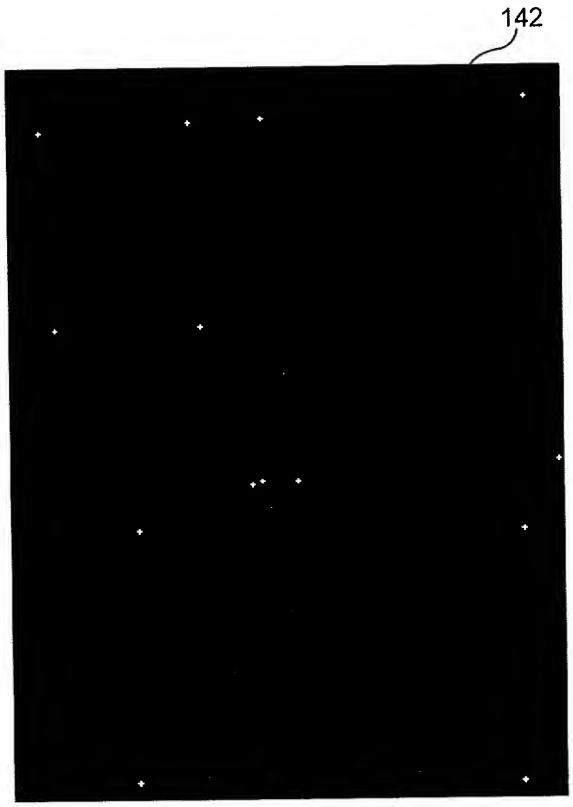


Figure 23

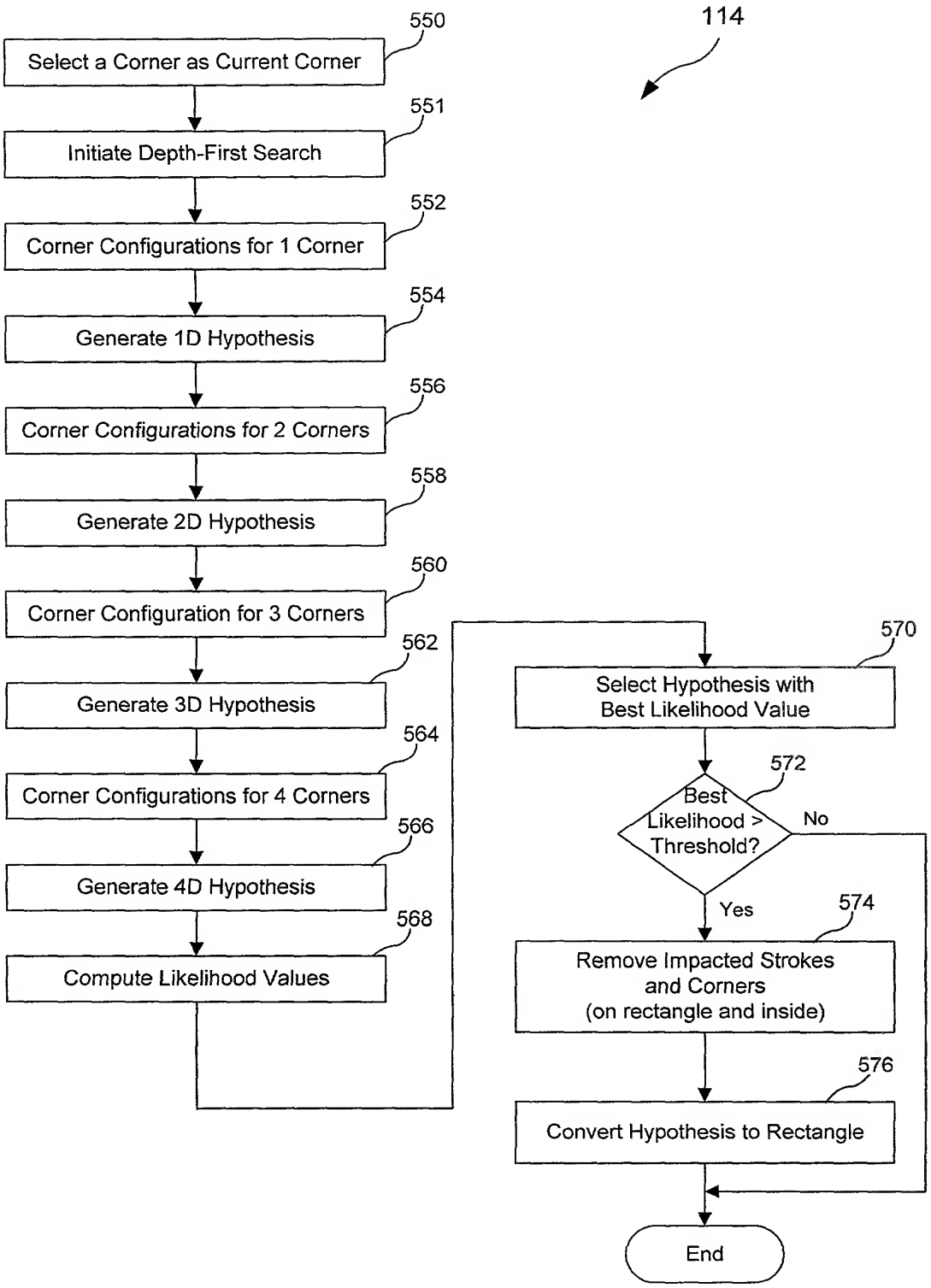

114
550
Select a Corner as Current Corner
551
Initiate Depth-First Search
552
Corner Configurations for 1 Corner
554
Generate 1D Hypothesis
556
Corner Configurations for 2 Corners
558
Generate 2D Hypothesis
560
Corner Configuration for 3 Corners
562
Generate 3D Hypothesis
564
Corner Configurations for 4 Corners
566
Generate 4D Hypothesis
568
Compute Likelihood Values
570
Select Hypothesis with Best Likelihood Value
572
Best Likelihood > Threshold?
No
Yes
574
Remove Impacted Strokes and Corners (on rectangle and inside)
576
Convert Hypothesis to Rectangle
End

Figure 24

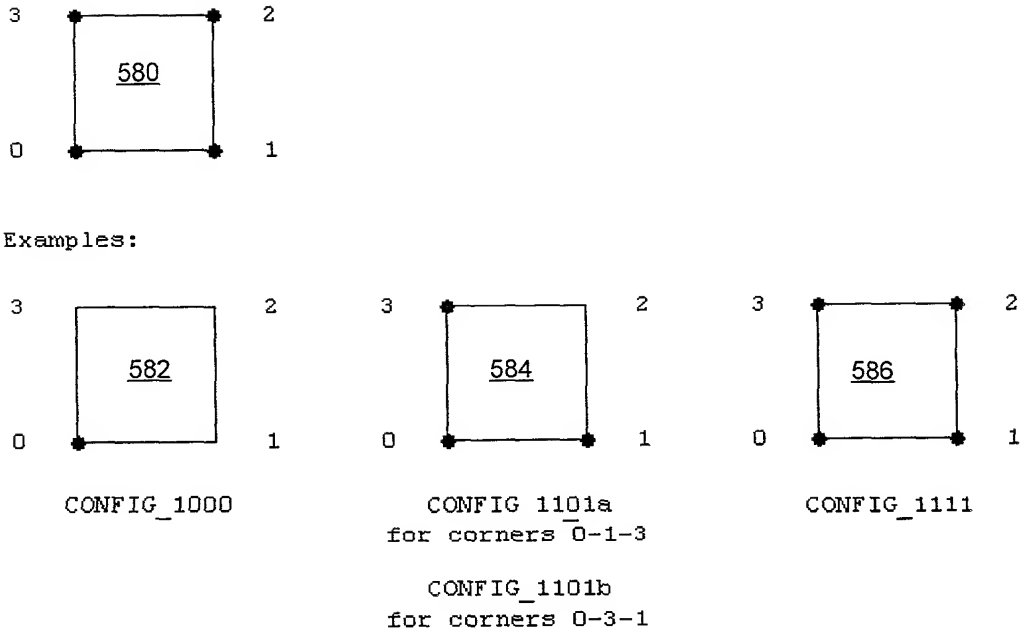


Figure 25

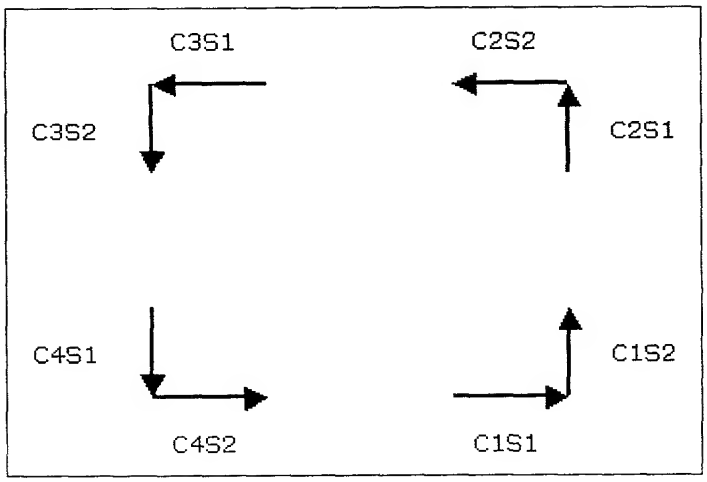


Figure 26

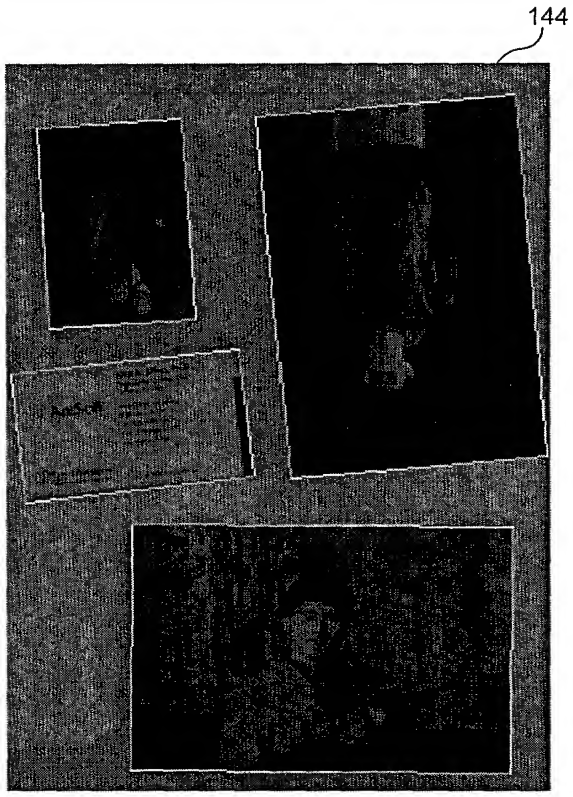


Figure 27

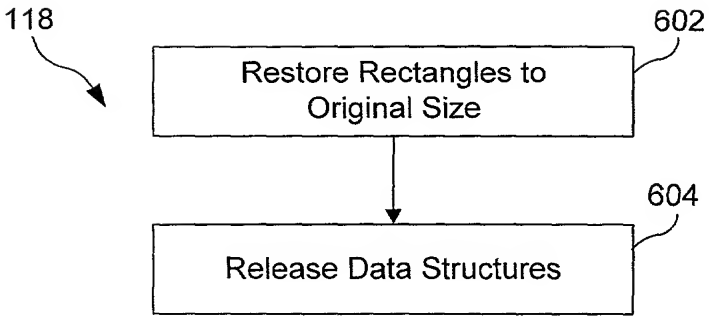


Figure 28